NASA JSC Photo S99-13845 by James Blair

The JSC Neuroscience Laboratory, from left, front: Edgar Benavides, Scott Wood, Jan Cook, Deborah Harm, Nicole Cleary, Laura Taylor; back: Millard Reschke, Troy Brown, Ajit Mulavara, Todd Schlegel, Brian Sekula, Lauren Merkle, Bill Paloski, Galen Kaufman, Jacob Bloomberg. Not pictured: Elisa Allen.

Preparing for extended space flight:

the human body's nervous system

As lengthy stays aboard the International Space Station loom in the near future, and plans for potential missions to Mars begin to unfold, the need for a better understanding of the human body's nervous system and its reaction to the microgravity environment becomes evident.

Exposure to the sensory conditions associated with the near weightlessness environment of space rearranges the relationships among signals from visual, skin, joint, muscle, and inner ear receptors in the body. Until some level of adaptation is achieved, astronauts often experience disturbances in spatial orientation, motion control, vision, and eye-head-hand coordination. Many of these same types of neurosensory, sensorimotor, and perceptual disturbances also are observed after crewmembers return to Earth.

Placing human beings in a microgravity environment removes them from their normal living conditions. "From the moment of conception, we are 1 g organisms," said Dr. Millard Reschke, NASA's chief of neuroscience at JSC. "We're conceived, born, reared, and work in a one gravity field. If you take away that gravitational component, then there are certain specific parts of the nervous system that are going to respond."

Neurophysiological function – brain, neurology, sensory physiology, and motor coordination – is an extremely important area of investigation particularly because it cuts across so many other bodily systems that are affected by the new gravitational environment. The responsibility for overseeing this critical area is that of the scientists in the JSC Neuroscience Laboratory, whose charge is to investigate the effects of space flight on the human nervous system, with particular emphasis on neurosensory and sensorimotor changes that occur in space.

Current topics of primary concern to the researchers are balance control and locomotion, eye-head coordination, vestibulo-autonomic function, neuroplasticity and artificial gravity.

Balance Control

Upon returning to Earth, every astronaut has some degree of disrupted balance control – difficulty maintaining upright stance. After short-duration flight, this condition usually persists for two to four days. However, after extended-duration flights, the Mir space station missions for example, this condition has been seen to persist for eight to 10 days, and some subtle effects persist even longer.

Disrupted balance control hasn't been considered a significant operational problem because it resolves by itself. Moreover, whenever the crewmembers land, there is always someone there to help them get around so that they do not have to worry about losing balance and falling. But extended-duration missions to distant planets may pose significant problems.

"Our concerns have to do with how astronauts will function after a six-month mission to Mars," said Dr. Bill Paloski, senior scientist in the Neuroscience Laboratory. "Without appropriate countermeasures, the astronauts will arrive there with severely disrupted balance control, and there won't be anyone there to help them. Because of this, we're actively seeking to understand the brain's adaptive mechanisms and to develop appropriate countermeasures."

The brain uses three primary sensory organ systems to help orient the body in space: the vestibular system (inner ear), the proprioceptive (body sense) system, and the visual system. The vestibular system has two components: the semicircular canals, which are sensitive to angular movements, and the otolith organs, which are sensitive to linear accelerations and gravity.

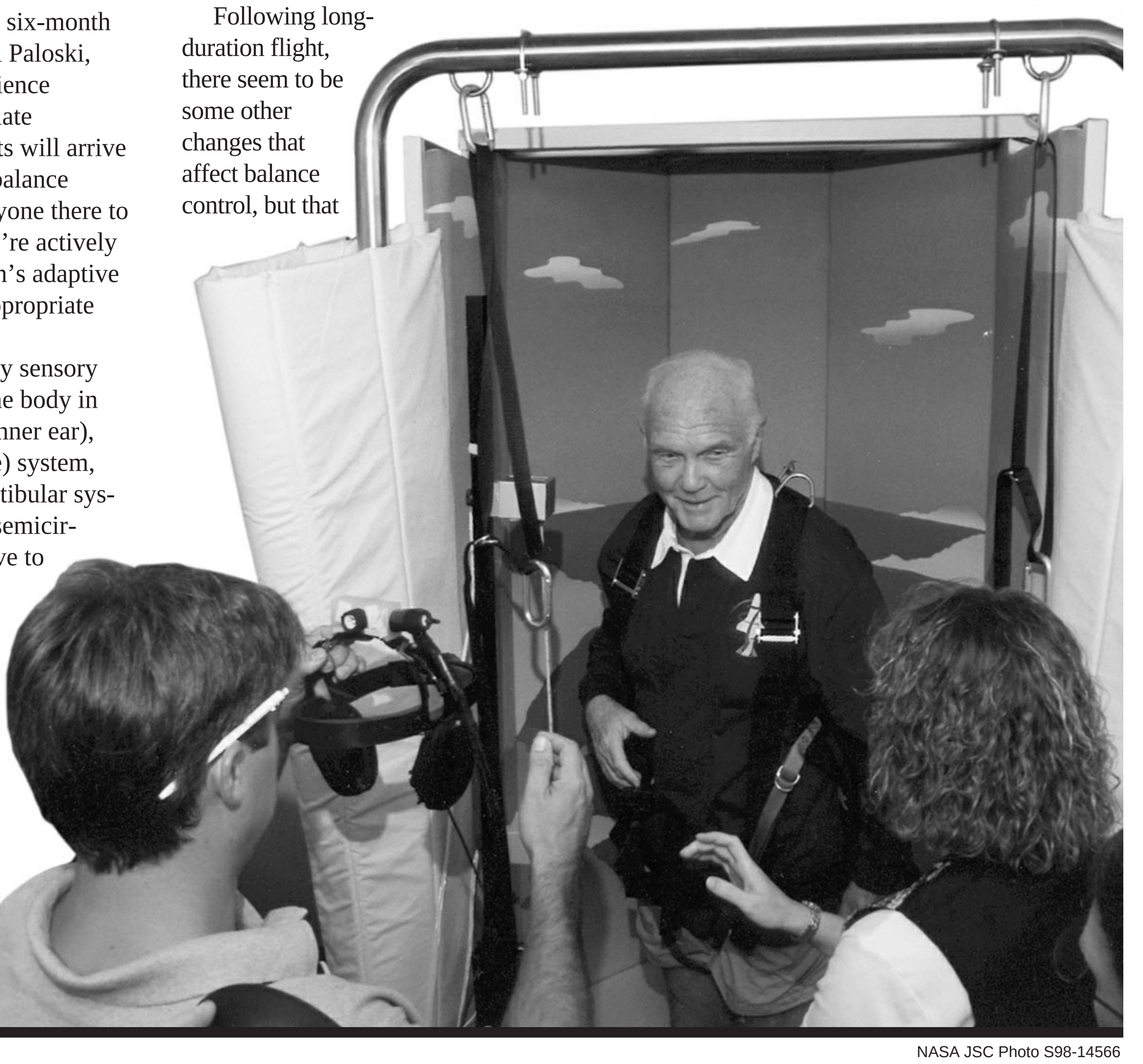
On Earth, the brain has learned through experience to interpret information from the otolith organs as either linear motion or tilt with respect to gravity. "When you tilt your head in a gravitational field, your brain knows that you've tilted your head due, in part, to changes in signals that the otolith organs send it," said Paloski. "When you move your head in space, there is no change in otolith signals because there is no gravity to work on that sensor. This initially confuses the brain, and can lead to some unusual perceptions, as well as to space motion sickness. Eventually the brain realizes that it should not expect those signals anymore, and so it adapts to zero gravity by relearning how to control movements without otolith tilt information."

Upon return to Earth, the otolith tilt information returns, and the brain becomes confused again, resulting in disorientation, disrupted balance control, and, in some crewmembers, motion sickness symptoms. These effects are much more profound following long-duration (Mir station) space flight than they are following short duration (space shuttle) missions.

Following long-duration flight, there seem to be some other changes that affect balance control, but that are not related to the inner ear. These concern changes in information from the proprioceptive system.

"We have sensors all about our body [embedded within our muscles, joints, tendons, and skin] that help our brain to know what position our limbs and joints are in and what kind of pressure we're feeling when we are sitting down or standing up," said Paloski. "Information from these proprioceptive sensors is also used by the brain to maintain balance control, to keep the body upright and oriented properly."

Some of the persistent balance and coordination problems that are seen after long-duration space flight have to do with how the brain reinterprets information from these sensors. "That's something we don't really see after short-duration missions. Short-duration missions are dominated by vestibular changes – changes in the inner



John Glenn on the posture platform.

NASA JSC Photo S98-14566